**Charles Worringham, Guest Contributor**
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# India's Ethanol Roadmap Off Course

*Accelerating Electric Vehicle Uptake Would Achieve Similar Goals Using a Fraction of the Land*

## Executive Summary

India's ambitious plans to bring forward the E20 ethanol-blending target to 2025, outlined in the 2021 Ethanol Roadmap, are aimed at reducing air pollution and emissions, supporting domestic agricultural demand, and reducing the drain on India's foreign exchange by limiting oil imports.

These laudable goals have nevertheless raised concerns about the long-term consequences on water use, food security and sugar exports as well as claims that the impact on pollution will be modest. This report examines a related concern that has not been addressed previously, namely the efficiency of land use and the quantity of land diversion that the policy implies. Analyses of these, and an alternative approach – enhancing goals for electric vehicle (EV) uptake – show that:

- Land is used far more efficiently generating renewable power for EV batteries than growing crops for ethanol. For example, to match the annual travel distance of EVs recharged from one hectare of solar, 187 hectares of maize-derived ethanol are required, even accounting for losses from electricity transmission, battery charging and grid storage.

**To match the annual travel distance of EVs recharged from 1ha of solar, the ethanol from 187ha of maize is required.**

- Full implementation of the Roadmap may require as much as 30,000 additional sq km to come under cultivation for ethanol. For comparison, this is up to half the land IEEFA expects may be required to generate clean electricity by 2050, but with very much smaller and more restricted benefits.

### *Recommendations*

- The scale and speed of India's ethanol blending plans should be critically reviewed with efficient land use as an important consideration.

- Further measures to underwrite ethanol-blending infrastructure and promote blended fuel use should be paused pending the outcomes of such a review, along with evaluation of new evidence questioning the claimed emissions benefits of blended fuels.

- The option of enhancing India’s EV adoption strategy as an alternative to further promotion of blended fuel should be actively and promptly considered.

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# Introduction

As a nation with a rapidly growing vehicle fleet, stubbornly persistent air quality challenges, ambitious greenhouse gas emissions targets and a sizeable oil import bill, it is perfectly understandable why India has decided not only to increase the ratio of ethanol blended with petrol to 20% but also to significantly accelerate the roll-out by bringing forward the E20 goal from 2030 to 2025.

To provide a framework for this initiative, an Expert Committee formed by NITI Aayog and the Ministry of Petroleum and Natural Gas prepared a report last year, setting out the background, assumptions and goals for ethanol blending. The Roadmap for Ethanol Blending in India 2020-2025[1] (hereafter 'the Roadmap') provides a rationale for the blending target with consideration of multiple financial, demand, supply and logistical factors. The Indian Government put its financial weight behind the plan even before the Roadmap's publication, expanding its interest subvention scheme for new ethanol distillation capacity in late 2020. In the recent Budget, it announced differential fuel excise provisions to incentivise the sale of blended fuel.[2] The ethanol blending ratio has steadily increased and has been reported as passing 9% as of January 2022.[3]

If the Roadmap meets its goals as forecast, the claimed benefits include reducing waste through persistent sugar surpluses, cleaner fuel, support for sections of the farming community, and lower import bills.

The policy does not come without risks, uncertain assumptions and unintended consequences, however, as several commentators have observed. Reliable feedstock surpluses are not guaranteed, distortions from selective feedstock price support may assist some farmers but disadvantage others, and the well-established environmental costs of sugar cane as a water-intensive crop may be exacerbated.[4,5] A separate concern is that the Roadmap sidelines parts of the nation's biofuels program, which had called for increased use of agricultural waste rather than food crops.[6]

More recently a new scientific report, if confirmed for India's blending sector, potentially undermines another of the Roadmap's major policy goals. The study re-evaluates the assumed benefit of blended fuel in the U.S., suggesting that far from being a lower emissions fuel, its total emissions profile could be at least 24% higher than for unblended petrol.[7] Commentary on the study concluded that:

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[1] NITI Aayog and Ministry of Petroleum and Natural Gas. Roadmap for Ethanol Blending in India 2020-2025: Report of the Expert Committee. June 2021.
[2] Economic Times. Budget 2022: Additional excise duty to promote ethanol blending. 2 Feb 2022.
[3] Money Control. 9% ethanol blending in petrol achieved; 20% target by 2025: Hardeep Singh Puri. 3 Feb 2022.
[4] The Print. India's ethanol production can't ride on surplus sugar and rice. Modi govt needs a way out. 12 Nov 2021.
[5] S&P Global. India's ethanol blending target faces feedstock challenges on its path. 2 Sep 2021.
[6] International Council on Clean Transportation. India, don't fall for ethanol: Roadmap leads national policy on biofuels off track. 26 Aug 2021.
[7] Lark, TJ et al. Environmental outcomes of the US Renewable Fuel Standard. PNAS, 1 March 2022.

> *“It is worth questioning the wisdom, logic, and ethics of continuing to use large expanses of our best farmland to produce a small amount of fuel at great environmental cost when better transportation alternatives exist.”*[8]

This report examines an aspect of the policy that has not been directly considered in published analyses. It extends IEEFA’s recent examinations of the interplay between the energy transition and India’s land use,[9] and of India’s potential in agrivoltaics,[10] by considering the implications of the Roadmap for new demands on land.

To address this, the report first analyses the relative efficiency of alternative ethanol feedstocks in terms of vehicle distance driven per unit of land used for producing the ethanol. To broaden the comparison, these values are compared with the equivalent relative efficiency measure for achieving the same vehicle travel distance by instead using land for additional solar generation to recharge EV batteries.

The second analysis estimates the potential effect of fulfilling the Roadmap’s goals on the absolute quantity of land that may be needed for the target levels of ethanol production, again, with solar land requirements included for comparison.

Several qualifying factors are also considered, such as partial co-production from the same land, crop cycle duration, the prospects for reliable feedstock surpluses, and the outlook for vehicle-grid integration.

## Comparative Land Use Efficiency

To estimate and compare the efficiency of land use required by the ethanol component of blended petrol between ethanol from sugar, grains and the alternative of solar generation re-charging EV batteries via the grid, a common metric of distance travelled per unit of land for each fuel source was obtained.

Inclusion of EVs in the comparison required the selection of a common reference vehicle with both petrol and EV variants. Although two-wheelers predominate in the Indian vehicle market, use of a four-wheeler for these comparisons is conservative, as the efficiency of electric vehicles (unlike petrol vehicles) is more affected by vehicle mass than by engine power, meaning that two-wheeler and three-wheeler EVs will generally have a greater efficiency advantage over their petrol counterparts than will four-wheelers.11 The Tata Tigor sedan was chosen for the comparisons, as a currently available model with petrol and EV variants sharing the same basic design, seating capacity and, though differing in weight because of the EV battery, identical dimensions.

The land use efficiency of the alternatives was calculated by multiplying several

[8] Hill, J. The sobering truth about corn ethanol. PNAS, 9 March 2022.
[9] IEEFA. Renewable Energy and Land Use in India by Mid-Century. Sep 2021.
[10] IEEFA. Agrivoltaics in India: Fertile Ground? Dec 2021.
[11] Weiss, M. et al. Energy efficiency trade-offs in small to large electric vehicles. Environmental Sciences Europe. 32:46. 2020.

variables outlined below.

For ethanol:

- A fuel efficiency value (for the ethanol component only) of blended petrol (13.6km/l of ethanol, as ethanol has 67% of the energy content of unblended fuel,[12] and a 20.3km/l fuel efficiency rating[13]).

- The yield of ethanol from feedstock. Those for different sugar refining processes were, respectively, 0.084, 0.0225 and 0.0108 l/kg of sugar cane for ethanol made directly from sugar cane, or via 'B' and 'C' molasses[14]). For grains (maize), a value of 0.380 l/kg was used.[15]

- Relevant recent crop yields: sugarcane 77,610kg/ha[16] and grains (maize) 2,965kg/ha.[17]

For EVs:

- Battery efficiency value for the equivalent vehicle (7.5km/kWh of battery electrical energy).[18]

- Annual energy generation of a typical solar park per unit land (630,720kWh/ha/yr) based on 400 kW/ha nameplate capacity[19] solar parks operating at a representative 0.18 capacity utilisation factor[20] for one year.

- An adjustment factor of 0.6054 (energy from EV battery/solar energy generated) to account for power losses between generation and driving, using 14% loss for EV charging, 12% loss in grid transmission, and a 20% amount to account for grid-scale battery or pumped hydro losses on the conservative assumption that all vehicle re-charging occurs at night.

Solar generation for one year is used, to be equivalent to the approximately 10-15 months crop cycle for sugar cane and the typical single annual crop for maize (about 2:1 Kharif vs. Rabi) as the major planned grain crop for ethanol.

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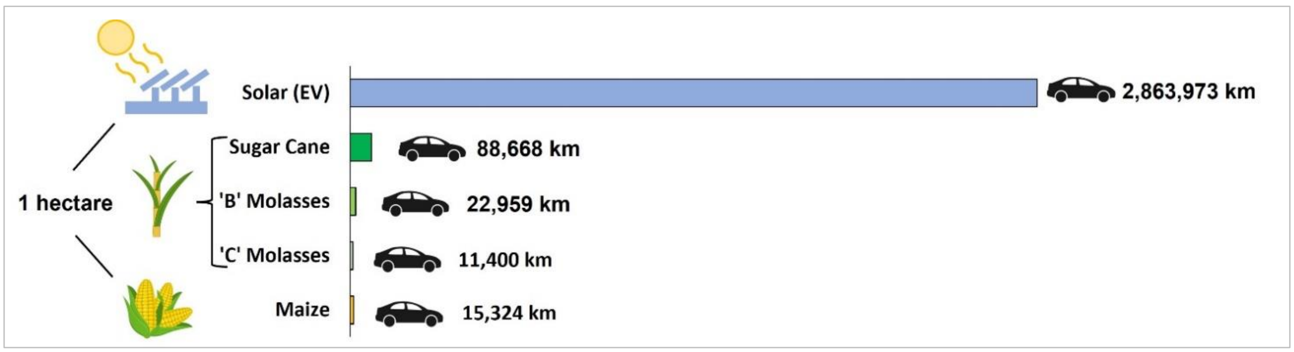
[12] U.S. Energy Administration. How much ethanol is in gasoline, and how does it affect fuel economy? (Updated 4 May, 2021).
[13] CarDekho. Tata Tigor specifications. Feb 2022.
[14] The Indian Express. Explained: Why govt is encouraging ethanol production. Updated 7 Nov 2019.
[15] NITI Aayog and Ministry of Petroleum and Natural Gas. Roadmap for Ethanol Blending in India 2020-2025: Report of the Expert Committee. June 2021.
[16] Indian Council of Agricultural Research. Area, Production and Productivity of sugar cane in India.
[17] ICAR–Indian Institute of Maize Research. Indian maize scenario.
[18] CarDekho. Tata Tigor EV review. Feb 2022. (To be conservative, the battery efficiency was based on an independent review's median distance of 195km for realistic conditions on a full charge of the 26kWh battery, rather than the manufacturer's specification of over 306km).
[19] 400kW/ha capacity, based on the average for India's three largest existing solar parks (Bhadla in Rajasthan, Pavagada in Karnataka, and Kurnool in Andhra Pradesh).
[20] JMK Research, IEEFA. Wind-Solar Hybrid: India's Next Wave of Renewable Energy Growth. Oct 2020.

The results of this comparison are shown in Figure 1.

Using one hectare of land for solar power generation is far more efficient than any of the agricultural ethanol feedstocks, driving an equivalent vehicle 32, 124, 187, and 251 times further than a hectare's worth of ethanol from sugar cane, 'B' molasses, maize and 'C' molasses, respectively.

Of the agricultural feedstocks, each hectare of sugar cane (when used to produce ethanol only) drives a notional vehicle about nearly eight times further than via 'C' molasses, and nearly four times further than via 'B' molasses. A hectare of maize, as the representative grain, is the second least efficient in terms of distance driven, only slightly better than ethanol from 'C' molasses.

## Figure 1: Vehicle Distance From 1 Hectare of Solar Energy or Ethanol From Sugar or Maize




*Sources: IEEFA calculations from NITI Aayog, Ministry of Petroleum and Natural Gas, ICAR and other data.*

Comparison of these estimates with those for the United States, where corn (maize) is the principal ethanol crop provides informative benchmarks.

One analysis estimates solar for EV recharging as being over 70 times more efficient in land use than corn (maize).[21] The much higher ratio of 187 estimated here for India is almost entirely explained by the lower yield, 2,965kg/ha in India as opposed to about 9,400kg/ha in the U.S. More intensive farming methods and inputs, more assured water, and highly selected corn varieties in the U.S. contribute to the difference.

For the solar to EV estimate, this same U.S. analysis reported a figure of 710,250 miles per acre of solar, which in metric terms is 2,824,505 km/ha – a difference of only 1% from the estimate obtained above for India and providing some confirmation of its validity.

A separate study also found a substantial 29-fold higher land use efficiency for solar than for corn-based ethanol in the U.S., with land use estimates broadly comparable

[21] Nussey, B. Making ethanol from corn is the least efficient use of farmland. Freeing Energy, 12 March 2021.

to those reported here.[22]

## *Second Crops and Co-production of Sugar, Fodder Ingredients and Food, Solar Generation Density*

These comparisons can be qualified by considering the agricultural yield for each of the alternatives from the same land over the same period.

Sugar cane used solely for ethanol is the most land-efficient of the distillation options, but it produces no sugar, whereas making the ethanol from 'B' and 'C' molasses yield about 7.4 and 8.9 tonnes of sugar per hectare of cane respectively, partially offsetting the land use inefficiency. Increasingly, 'B' molasses is used for ethanol, and other products such as juice and syrup are also playing a part.

Although this co-production of sugar has real economic value, any increased production for ethanol would need to account for its limited nutritional value and the environmental costs, especially if it displaced other crops.

Unlike sugar cane, maize growing has some potential for the same land to produce a second crop, predominantly as a rabi crop such as wheat, although yields are very dependent on soil moisture levels on rain-fed farmland and there is significant geographical variation in crop rotations. Maize for ethanol also creates the by-product of Distiller's Dried Grains with Solubles (DDGS), used largely in poultry fodder. Approximately 900kg of DDGS comes from each hectare of maize. Although this may substitute for soya used in fodder it still represents much less efficient land use if considered in terms of direct food production for human consumption from the equivalent land.

An additional consideration is that the renewable energy used to power the equivalent EVs need not be generated by high density solar parks. If it were to come from agrivoltaic projects at one-fifth or even one-tenth of the land density, it would still be many times more land-efficient than ethanol, while enabling agricultural production to be largely maintained. Moreover, although not considered here, EV charging from additional wind generation would further widen the land efficiency gap between renewable energy and increased ethanol use.

These off-setting factors have effects in both directions but make little fundamental difference to the disparity in land-use efficiency of the various alternatives.

## *EV Battery Charging and Future Vehicle-Grid Integration*

A simplifying assumption was made in these comparisons that all EVs would be charged overnight and therefore require solar energy to be stored in batteries or pumped hydro, leading to greater power losses. This assumption errs on the conservative side in the EV-ethanol comparison. A night-time charging pattern

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[22] Pontau P. et al. Assessing land-use impacts by clean vehicle systems. Resources, Conservation and Recycling. February 2015.

would add to evening peak demand while also requiring large investment in additional grid-scale storage.

India has several pilot projects already in train to evaluate different forms of vehicle-grid integration. Together with analysis of technical, economic and regulatory issues involved, some of these are described in a joint Shakti Foundation-Alliance for an Energy Efficient Economy report on the subject.[23] The authors model a pathway from 'Simple EV charging' as currently practised, through 'Smart Charging' (known as V1G) and 'Aggregated Smart Charging' to 'Large Scale bi-directional charging' (V2G), which would promote a range of measures to ensure that the electrical grid and vehicle charging patterns are complementary.

If India adopts such a pathway, far from acting as a badly timed and capital-intensive additional load on the grid, EV batteries could initially minimise and then neutralise the effects of this load, and eventually make a substantial net positive contribution to the grid stability and renewable power generation efficiency, given appropriate rules, market reforms and incentives.

The potential for vehicle-grid integration addresses one of the potential disadvantages of any decision to promote EVs rather than greater levels of ethanol use.

**Vehicle-grid integration addresses one of the potential disadvantages of any decision to promote EVs rather than greater levels of ethanol use.**

## Absolute Land Requirements

The second analysis estimates how much additional land could potentially come under cultivation for ethanol blending if the Ethanol Roadmap meets its stated 2025-26 targets, taking account of production that would be based on reliable surpluses and therefore not require new cultivation, and considering only new ethanol for petrol-blending, not for other purposes. The focus of the analysis remains on sugar and maize but some alternatives and their disadvantages are also considered.

A base year of 2021-22 is used, during which India is projected to use 4.37 billion litres of ethanol for petrol blending. The Ethanol Roadmap projects 10.16 billion litres being used for this purpose in 2025-26. As the goal is to consider the land demands over and above current levels, the increase (5.79 billion litres) is used for the estimates below – comprising an additional 2.2 billion litres from sugar and 3.59 billion litres from grains, a near doubling and more than a quadrupling, respectively,

[23] Das, S, Deb S. Vehicle-grid integration: A new frontier for electric mobility in India. Shakti Sustainable Energy Foundation and Alliance for an Energy Efficient Economy. Oct 2020.

of figures presented in Table 7.2 of the Roadmap for the base year.

To estimate likely land requirements for the expansion of ethanol, the potential use of surplus feedstock must be accounted for. The Roadmap is very confident in its assertion that excess stocks and surplus production will be sufficient, but any running-down of stocks can only be a temporary strategy, and continued surpluses are certainly not guaranteed, especially for drought years and for grain-based ethanol. While record production levels are expected for this year,[24] there have been warnings that the dependence on surplus sugar and other feedstocks carries risks,[25,26] which have been given greater impetus with the publication of the recent IPCC Working Group II report, warning that agricultural production in South Asia, along with other regions, is likely to come under increasing pressure from the changing climate.[27]

## *Potential Feedstocks Other Than Sugar and Maize*

Production and surplus levels of rice are high, but it may at best provide a stop-gap source for ethanol. Union Food Secretary Sudhanshu Pandey has been quoted as saying that rice usage for ethanol is only "minuscule and transitory".[28] Wheat can also be used as a source of ethanol and, as one of the other major crops receiving a Minimum Support Price, its production has been rising but there have been no serious proposals for ethanol from wheat to date.

For both rice and wheat – and other staple or high nutrition value crops – diversion to ethanol production is problematic. Given continued high levels of child malnutrition, stunting and mortality in India, which has fallen to 101st place in the latest Global Hunger Index, as well as flat per capita grain consumption and inadequacies in the public distribution network, some have argued against any diversion of Food Corporation of India (FCI) stocks and even question whether such stocks genuinely represent a surplus at all.

Damaged grains are another suggested source but to the extent they represent wastage, often through prolonged and improper storage, the priority should be to prevent waste rather than promote dependence on it as a new feedstock, which also carries the risk of disincentivising waste reduction measures. The quantity of available damaged grains used in the Roadmap estimates has also been reported as an over-estimate.[29]

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[24] Times of India. Foodgrain production to reach at record high of 316 MT in pandemic-hit year: Gov. 17 Feb 2022.
[25] The Print. India's ethanol production can't ride on surplus sugar and rice. Modi govt needs a way out. 12 Nov 2021.
[26] S&P Global. India's ethanol blending target faces feedstock challenges on its path. 2 Sep 2021.
[27] IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. February 2022.
[28] Indian Express. Centre allocates 78,000 tonnes of rice from FCI for ethanol production. 16 Jun 2021.
[29] The Print. India wants to use food grain stock for ethanol. That's a problem in a hungry country. 1 Jul 2021.

## *Additional Ethanol From Sugar*

Sugar surpluses have been consistent and growing, and the Roadmap states that nearly one-fifth of production – 6 million tonnes for 2019-20 – was excess to consumption. Indeed 7.2 million tonnes were reported to have been exported in 2020-21.[30] While such surpluses may meet the ethanol goals allocated to sugar (at the expense of sugar exports) in the short term, continued surplus production would be needed if additional land use is to be avoided.

Were surpluses to prove unreliable over time, how much additional land might come under sugar cane cultivation? This is heavily dependent on the mix of distillation methods used. To date, sugar-based ethanol has primarily come from ‘C’ molasses, in a process that does not reduce sugar production, but the Roadmap calls for increased use of ‘B’ molasses (with reduced sugar production) as well as direct use of sugar products including sugar cane juice and related products (typically resulting in little or no sugar being produced).

As sugar is a high yield crop, relatively limited amounts of land are likely to be required if sugar surpluses were insufficient. This is illustrated in Figure 2A, which shows the land requirement for each of the three distillation methods as a function of the proportion of additional ethanol made from surplus sugar rather than new cultivation.

Even with the most land-intensive of the distillation options (from ‘C’ molasses), additional land use would not be extreme unless surpluses were minimal. Using ‘C’ molasses would also produce more sugar and increase the surplus, which would itself limit the need for extra cultivation.

Producing ethanol directly from sugar cane without co-production of sugar is the most land-efficient option for sugar, and such direct production is now under development, exemplified by a new mill in Maizapur, Uttar Pradesh.[31]

Figure 2 also shows the requirement for the equivalent solar land for EV battery recharging, corresponding to the total distance driven from the use of the planned additional ethanol. These are fixed amounts that do not change with the proportion of ethanol coming from feedstocks and are shown as horizontal lines for solar park (dashed) and agrivoltaic (dotted) configurations, the former requiring one-fifth of the land of the latter).

If surplus production does not consistently support all or almost all of the expanded sugar-based ethanol, increased cultivation could rapidly overtake the land required for equivalent solar recharging of EV batteries. For example, a shortfall leading to sugar surpluses meeting only 80-90% of the targets might bring into production more land under sugar cane than would be needed by solar land accomplishing the same goal.

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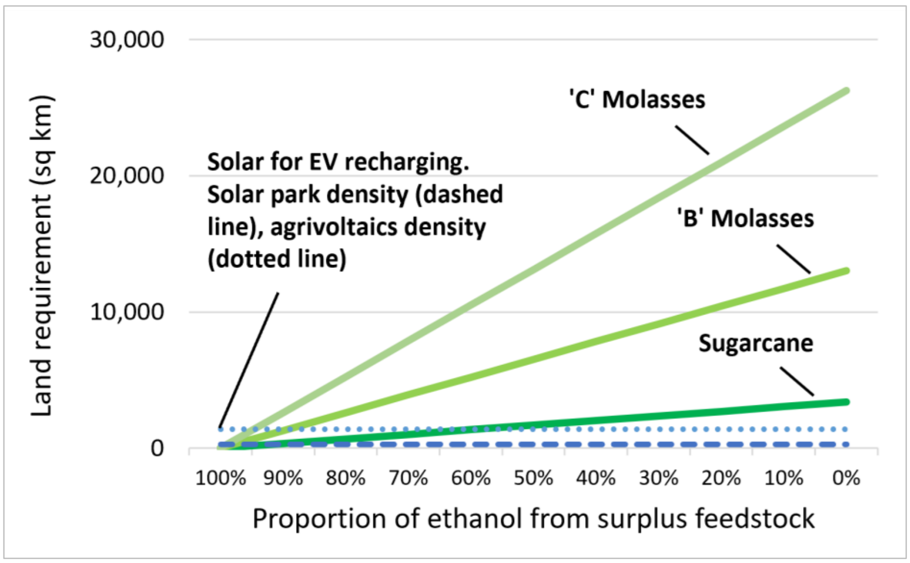
[30] Reuters. Indian sugar exports slow as global prices correct, rupee firms. 11 Jan 2022.
[31] Indian Express. This new UP sugar mill will produce no sugar, only ethanol. 28 Feb 2022.

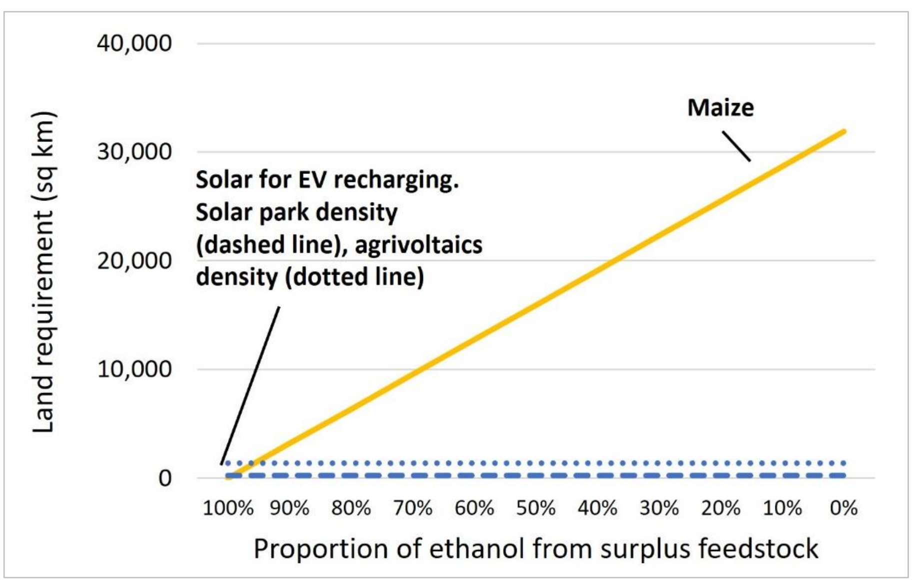
In summary, sugar surpluses appear to be sufficient, and probably sufficiently reliable, to minimise new land requirements in the immediate future. Nevertheless, financial incentives for ethanol blending may already be encouraging more sugar cane growing, with the area under cultivation up by 3% to 5,455 square kilometres in the 2021-22 season. Even if such growth is not strictly warranted, it runs counter to India’s efforts to rein in the excessive water use and lower soil fertility attributed to sugar cane growing.

## Figure 2: Potential New Land Requirements for Ethanol

### A: Sugar-based ethanol




### B: Grains-based ethanol




*Sources: IEEFA calculations from NITI Aayog, Ministry of Petroleum and Natural Gas, ICAR and other data.*

## *Additional Ethanol From Maize*

In recognition of the need to avoid the water consumption costs of additional sugar, the Roadmap envisages most of the new ethanol coming from grains. As noted above, maize is seen as the dominant grain for this purpose. In order not to displace current uses of maize (principally fodder, food manufacturing, starch and a variety of industrial processes), a substantial increase in maize production would be needed, as other commentators have noted.[32,33]

**The Roadmap appears to promote a major expansion of maize cultivation.**

Despite the optimistic outlook in the Roadmap, maize surpluses have not been reliable. For example, the USDA GAIN database shows that ending stocks for the year to November 2021 were down by 800,000 tonnes from the previous year.[34] The Roadmap suggests that well over one-third of all India's maize production is surplus, at 10.3 million tonnes. The USDA database reports production exceeding domestic consumption by only 1.4 million tonnes for 2020-21. Other sources show production as currently almost fully committed to fodder, food or industrial uses and only 6% of production – approximately 1.8 million tonnes – available for export or other uses, far short of the quantity needed.[35]

Figure 1B shows the land requirements for the additional ethanol from maize earmarked as the grains component of the Roadmap's goals. As much as 30,000 sq km of maize could be required by 2025-26 to meet these goals. There is no plausible data to suggest that surplus maize could provide more than a fraction of the required feedstock, and any diversions would come at the expense of food products, animal fodder or industrial customers, so the Roadmap appears to promote a major expansion of maize cultivation.

## *Additional Solar Generation*

Figures 2A and 2B illustrate two options for the equivalent solar generation, which is estimated to require a total of 11GW capacity relative to the 2021-22 base year. If conventional high density solar parks are used, 275 sq km are required. If generation is instead dispersed at one-fifth of the density in agrivoltaic generation, 1,375 sq km are needed. In either case, the land requirements are negligible compared to any of the ethanol crops. Moreover, sugar and maize can be grown only on suitable land with available water, while there is a much larger stock of land

[32] International Council on Clean Transportation. India, don't fall for ethanol: Roadmap leads national policy on biofuels off track. 26 Aug 2021.
[33] Business Standard. Ethanol blending on track but grain-based distillation could be a challenge. 16 Oct 2021.
[34] USDA GAIN India Grain and Feed Update (Report IN2022-0002) - January 2022.
[35] FICCI, PWC. Maize vision 2022. 2018.

suitable for solar generation, which would enable locations to be chosen with much greater flexibility and much less conflict with agricultural output.

The 11GW of solar capacity needed to substitute for additional ethanol is itself a significant challenge. It would need to be added to current installation goals to ensure that the substitution does not draw on coal generation, which would partially defeat the purpose of the substitution. It is equivalent to 22% of India’s current 50.3GW of solar capacity, or just over 10% of the current 105.9GW of total renewable capacity. However, with annual solar installation having achieved 11.5GW to January 2022, and with further acceleration in this rate, it can be expected to form a smaller task relative to the likely capacity additions by the 2025-26 target year, equivalent to just a few months’ worth of installation. The 11GW estimate is itself likely on the high side, as it makes no allowance for any vehicle-grid integration.

# Recommendations

This report points to far greater land use efficiency, in both relative and absolute terms, in meeting the key goals of the Roadmap through renewable power generation than by further expansion of ethanol blending. The policy choices will affect multiple social, environmental and economic issues of great importance for India, prompting the following recommendations:

- The scale and speed of India’s ethanol blending plans should be critically reviewed with efficient land use as an important consideration.

- The ramifications of India’s ethanol policy are far-reaching and its implications for land use appear not to have been adequately considered. A careful evaluation of both the target blending level and its timeframe is needed, considering land use, food security and other issues confronting the rural sector in particular.

- Further measures to underwrite ethanol-blending infrastructure and promote blended fuel use should be paused pending the outcomes of such a review, along with evaluation of new evidence questioning the claimed emissions benefits of blended fuels.

- Budgetary and other measures to further subsidise the sugar-refining sector and ethanol blending should be paused to allow this review. This would also allow a fuller assessment of risks associated with such support, which include distortions of agricultural markets and the potential of stranded assets if ethanol blending proves not to be viable in the long-term. Recent evidence that ethanol blending may not accomplish emissions reduction should be included in any review as it is one of the policy’s key goals.

- The option of enhancing India’s EV adoption strategy as an alternative to further promotion of blended fuel should be actively and promptly considered.

- The electric vehicle sector is only at a nascent stage, yet India has already committed to its promotion. The increasing pace of the global vehicle fleet’s electrification may accelerate uptake of EVs even faster than expected. To achieve the key goals of the Ethanol Roadmap, the alternative mechanisms – enhanced EV uptake, additional renewable generation capacity installation to allow zero-emissions recharging, and accelerated vehicle-to-grid integration – need to be evaluated.

# About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

# About the Author


## Charles Worringham

Dr. Charles Worringham is an Australia-based former academic and now independent researcher and a guest contributor for IEEFA, with a special interest in India's energy transition.